Understanding Rwanda's Soil Quality and Management Practices

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Abstract

The UN reports the world's population to grow to 9.8 billion by 2050, with most Sub-Saharan countries doubling their population between 2017-2050[1], Rwanda included with 1259 habitants per square mile[2]. The farmers in Rwanda undergo high pressure to produce more to feed the growing population, and to achieve this goal they need to rely on up-to-date, easy-to-interpret soil quality data to inform their agronomic practices. In 1980s, USDA-NRCS collected soil samples in Rwanda, and by using new technologies available at Kellogg Soil Survey Laboratory, it is clear that Rwanda's soil are mostly acidic, highly-weathered, with high levels of Iron, with low levels of Nitrogen and organic matter. This research will eventually provide recommendations of management practices to improve Rwanda's soils quality.

Objectives

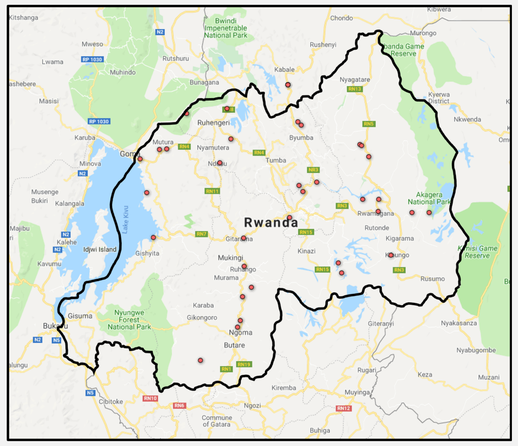
- To provide data and knowledge that will help farmers, government, and other organizations to design sustainable agronomic management styles and practices to improve Rwanda's soils quality.
- To provide the understanding around how Rwanda's soil ecosystem is negatively affected by various factors including time, management, climate, topography, etc.
- To contribute to an up-to-date, easy-to-interpret, and reliable data on Rwanda's soil quality.

Methods

- 116 samples from 24 sites in Rwanda, collected in 1981 and 1984 by the USDA-NRCS
- followed standard analysis protocols developed and published in Kellogg Soil Survey Laboratory Methods Manual, version 5.0[3]
- particle size distribution, cation exchange capacity, base saturation, pH, total carbon-nitrogen-sulfur, electrical conductivity, bulk density, water retention (15 bar – wilting point), beta-glucosidase enzymes, calcium carbonate equivalent, iron and aluminum dithionite, iron and aluminum oxalate

Beta-glucosidase enzyme analysis, Kellogg Soil Survey Laboratory, USDA-NRCS

Field Day with Neil Dominy, Nebraska State Soil Scientist, USDA-NRCS



Project Sample Sites Locations across Rwanda (Google Fusion Table)

Figure 1: Soil Quality Indicator Averages

	Full Profile		Upper 50 cm		
Analysis	Number of Samples	Average	Number of Samples	Averages	Units
Clay	113	34.2	44	28.7	%
Silt	113	20.2	44	25.3	%
Sand	113	45.6	44	43.7	%
Bulk Density	70	1.4	44	0.8	g/cm3
Water Retention (15 bar)	116	18.1	44	18.7	%
Total Carbon	116	2.9	44	2.7	%
Total Nitrogen	116	0.2	44	0.3	%
Total Sulphur	116	0.0	44	0.0	%
Iron Dithionite	113	3.3	44	3.1	%
Aluminium Dithionite	112	0.6	44	0.7	%
Organic Carbon	116	2.8	44	3.3	%/100g
C:N Ratio	78	13.4	44	13.5	-
CEC	116	19.9	44	23.4	Milliequivalent/100g)
Base Saturation	113	31.1	44	29.4	% (of cmolc/Kg - total CEC)
PH	116	5.3	44	5.2	Units -log[PH]
Electrical Conductivity	104	0.8	44	1.1	dS/m
Enzyme BG	100	8.7	44	13.6	mg/p-nitrophenol/kg OD/h
Calcium Carbonates	116	1.9	44	0.0	%

Figure 2: Total Carbon and Nitrogen Analysis, upper 50 cm

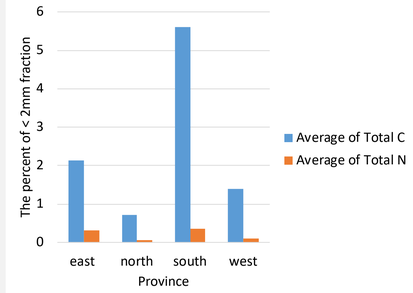


Figure 3: Cation Exchange Capacity Analysis, upper 50 cm

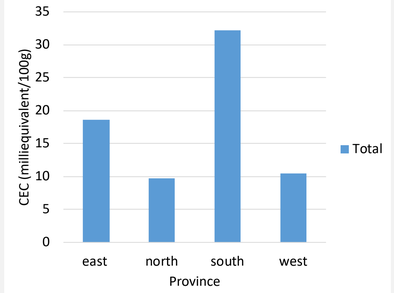


Figure 4: pH Analysis, upper 50 cm

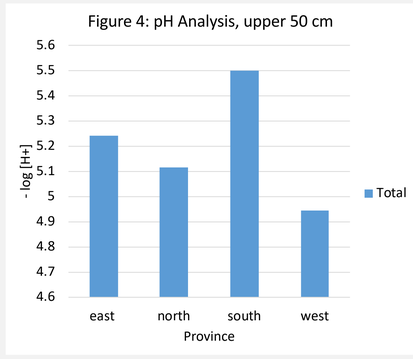


Figure 5: Bulk Density Analysis

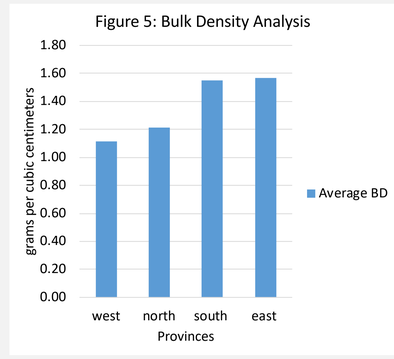


Figure 6: Iron Dithionite Analysis, upper 50 cm

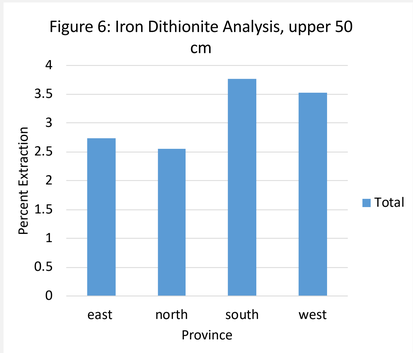
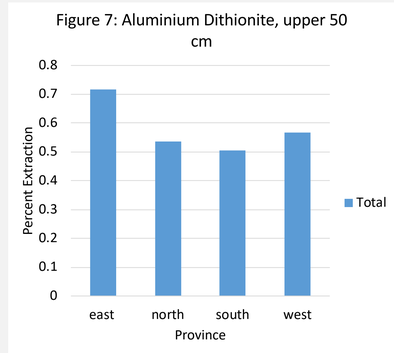


Figure 7: Aluminium Dithionite, upper 50 cm



Results & Discussion

- There are no significant differences between averages for full profile and upper 50 cm of all pedons.
- Differences like the average clay content decreasing from an average of 34.2% in the full profile to 28.7% for the upper 50 cm could be due to the fine clay particles being washed or blown away, or carried down deeper into the profile by water infiltration.
- Average soil texture is most likely to fall under sandy loam, sandy clay loam, loamy sand, or sandy clay due to high levels of sand (45.6% on average, relatively high levels of clay (34.2% on average), and low levels of silt (20.2% on average)
- For all soil quality analysis, the upper 50 cm data can provide reliable knowledge about the quality of the soil, as it is the region where most plant, microbial, and human activity occurs.
- Distinct patterns in the data arise when sorted by provinces.
- North and West Provinces have lower Total C and N, lower CEC, and lower pH → chemically less ideal for plant growth than soils in South and East
- Categorizing the data by province captures geographical differences due to variable natural physical geography characteristics which affect soil development and properties.
- Due to time and language constraint, the management practices of 1980s were not thoroughly studied since the data are very old, it was difficult to locate the French-written management practices files.

Conclusion

- Acidic soils with high levels of Fe and Al, low levels of total carbon, and low pH indicates a general poor quality of Rwanda's soils.
- Additions of lime, fertilizers, and manure to fields, and other measures to increase organic matter content and pH would have been very critical recommendations to improve agriculture in Rwanda.
- A follow-up UCARE will look at the analytical comparison between 1980s soil quality data and current data to investigate how soil quality has changed over a period of 35 years and how management practices have influenced those changes.
- Data from this project and the follow-up UCARE might be used to calibrate the Rwanda's mid infrared (MIR) spectroscopy database.

References

1. United Nations [UN]. (2017, June 21). World Population Projected to Reach 9.8 billion in 2050, and 11.2 billion in 2100. retrieved from https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html
2. NISR. (2012). Population Size, Structure, and Distribution. Retrieved from http://statistics.gov.rw/file/2907/download?token=i09m0Bly
3. United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS). (2014). Kellogg Soil Survey Laboratory Methods Manual. Soil Survey Investigations Report No. 42, Version 5.0.

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